CONSTRAINTS ON PDF UNCERTAINTIES FROM CDF

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Recent electroweak measurements and jet physics results from CDF which constrain the parton density functions (PDFs) are presented. Measurements of the W charge asymmetry, W and Z as well as jet cross sections based on k_T and midpoint algorithm with up to 1 fb^{-1} Run II data are discussed.

Electroweak measurements at the Tevatron provide precision tests of the Standard Model (SM) and searches for physics beyond the SM. They also supply important constraints on the PDFs and are a significant input to physics at the Large Hadron Collider at CERN. At hadron colliders W and Z bosons' hadronic decays are overwhelmed by QCD background and the identification takes place through the leptonic decays. W bosons are selected by demanding an isolated lepton with $E_T > 20$ GeV and missing transverse energy $E_T^{miss} > 25$ GeV. The Z boson signature is two isolated leptons with opposite charge and $E_T > 20$ GeV which fit the Z mass.

CDF has measured the inclusive W and Z cross sections in dierent lepton decay channels and these are summarized in Figure 1. The data agrees with the NNLO predictions[1]. The dominant uncertainty is the luminosity (6%) followed by PDFs (2–3%) and lepton identification (1–3%).

In the electron channel, CDF extended the W (electron channel) cross section measurement into the very forward region of $1.2 < |\ | < 2.8$ using a calorimeter seeded tracking. The analyzed data corresponds to 223 pb^{-1} and is complementary to the CDF central cross section measurement[2]. The measured cross section is $= 2.796 \pm 0.013(stat) + 0.095(syst) - 0.090(syst) \pm 0.168(lum)$ nb. The result is in agreement with previous CDF measurements in the central region and with theoretical estimates. For the first time CDF evaluated the central to forward visible W cross section ratio. In this way most of the luminosity uncertainty cancels out and the

for the CDF Collaboration

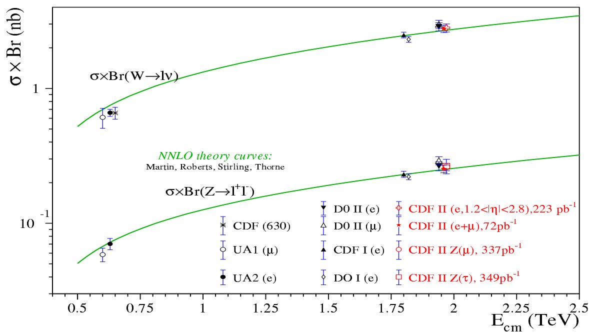

Figure 1. Summary of the measured W and Z cross sections and their comparisons with NNLO for all lepton channels as a function of centre of mass energy.

corresponding remaining uncertainty is estimated conservatively to be 1%. The experimental ratio is

$$R_{exp} = \frac{(\text{visible,central})}{(\text{visible,forward})} = 0.925 \pm 0.033$$

to be compared to the NLO ratio of acceptances

$$\left.\frac{A(\text{central})}{A(\text{forward})}\right|_{CTEQ} = 0.9243^{+0.023}_{-0.030}(PDF) \pm 0.0043(NLO - NNLO)$$

$$\left.\frac{A(\text{central})}{A(\text{forward})}\right|_{MRST01E} = 0.9414^{+0.010}_{-0.012}(PDF) \pm 0.0044(NLO - NNLO).$$

Unlike the inclusive cross sections which are limited by the uncertainty on the luminosity the uncertainties of the ratio measurement will go down with statistics and will provide in the future a significant constraint on the PDFs.

Measurements of the forward-backward charge asymmetry in $p\bar{p}$ $W^{\pm} + X$ provides important input on the ratio of the u and d quark components of the PDFs. Since u quarks carry, on average, a higher fraction of the proton momentum (x) than d quarks, a W^+ produced by $u\bar{d}$ W^+ tends to be boosted in the proton direction (forward) and a W^- tends to be boosted in the anti-proton direction (backward). This results in a nonzero forward-backward charge asymmetry. In the leptonic decay of the W boson the longitudinal momentum of the neutrino can not be experimentally determined and hence the rapidity on the W, y_W, is not directly measured.

CDF instead measures

$$A(\eta_l) = \frac{d\sigma(W^+)/d\eta_l - d\sigma(W^-)/d\eta_l}{d\sigma(W^+)/d\eta_l + d\sigma(W^-)/d\eta_l} \approx \frac{d(x)}{u(x)}, \qquad (1)$$

where η_l is the lepton pseudorapidity. By assuming the $W \to l\nu$ decays are described by the Standard Model $V-A$ couplings, $A(\eta_l)$ probes the PDFs. The $V-A$ couplings in the leptonic W decay cause the lepton to be preferentially emitted opposite to the W boson flight direction. The lepton asymmetry, $A(\eta_l)$, is a convolution of the competing W production and $V-A$ decay asymmetries. Direct sensitivity to the PDFs would be improved by reducing the decay asymmetry effect. The unknown longitudinal component of the neutrino momentum is a smaller effect for leptons with high E_T than for those at low E_T. CDF exploited this for the first time by separating the asymmetry measurement into two bins of electron E_T for $W \to e\nu$ events. For a given η_e, the two E_T regions probe different y_W, and therefore x. As a result, measuring the electron asymmetry separately in two bins allows also a finer probe of the x dependence. Figure 2 shows the electron asymmetry for two different E_T regions[3], based on 170 pb^{-1} of Run II data. Predictions from CTEQ[4] and MRST[5] PDFs, which fit the previous CDF results[6], are shown for comparison.

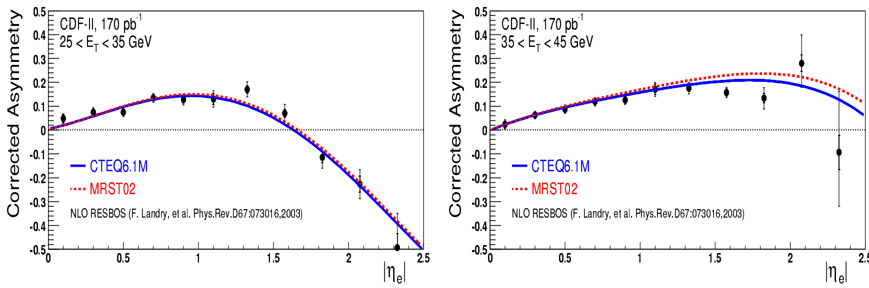

Figure 2. The measured electron asymmetry, $A(\eta_e)$, is plotted and predictions from the CTEQ 6.1M (solid) and MRST 02 (dashed) PDFs are compared using NLO RESBOS calculation. Left: $25 < E_T < 35$ GeV; Right: $35 < E_T < 45$ GeV.

Another way to improve the direct sensitivity to PDFs is to reconstruct the W boson rapidity. CDF is currently developing a new analysis method which directly reconstructs the W rapidity from $W \to e\nu$ data. The new method determines the neutrino longitudinal momentum by constraining the W mass, up to a two-fold ambiguity. This ambiguity can be partly resolved on a statistical basis from the known $V-A$ decay distribution for the centre of mass decay angle and from the $W^{\pm}$ production cross section as function of y_W, d/dy_W. The new method is an iterative MC based procedure and first preliminary studies show that it has smaller statistical errors and a greater sensitivity to the PDFs than the lepton asymmetry measurements.

Figure 3 shows the ratio of the inclusive jet production cross section using the longitudinally invariant kt algorithm [7] (left) and the midpoint cone algorithm [8] (right) for jets with $p_T > 54$ GeV and $1.6 < |y| < 2.1$ over theory. The kt algorithm based measurements are fully unfolded to the hadron level and the data is compared to pQCD NLO calculations as determined using JETRAD. The theoretical predictions are corrected for underlying event and hadronization effects. The midpoint jet measurements are fully unfolded to the parton level. The data is compared to pQCD NLO calculations as determined using EKS. The jet cross section measurements from both algorithms will place important constraints on the gluon PDF at high x.

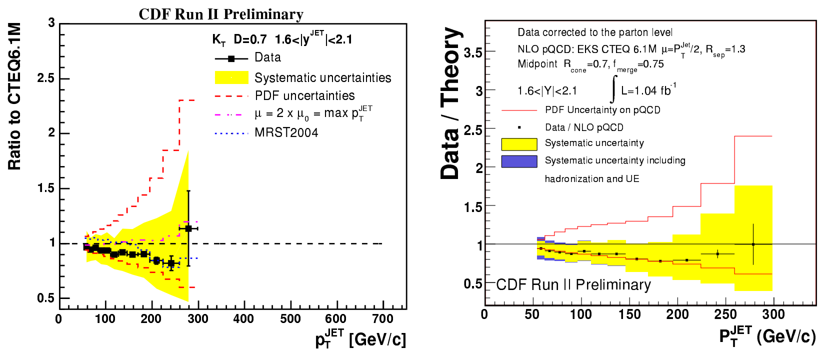

Figure 3. Ratio of measured and theoretical inclusive jet cross sections using kt (left, 0.98 fb^{-1}) and midpoint (right, 1.04 fb^{-1}) algorithm as function of jet P_T for $1.6 < |y| < 2.1$.

References

1. C. Anastasiou et al., Phys.Rev D 69 094008 (2004).
2. D. Acosta et al., Phys.Rev.Lett. 94 091803 (2005).
3. D. Acosta et al., Phys.Rev. D 71 052002 (2005).
4. J.Pumplin et al., J. High Energy Phys. 07 012 (2002).
5. A.Martin et al., Eur. Phys. J. C 4 463 (1998).
6. F.Abe et al., Phys. Rev. Lett 81 5748 (1998).
7. S.D.Ellis and D.E. Soper, Phys. Rev. D 48, 3160 (1993).
8. G.C.Blazey et al., hep-ex/0005012 (1999); S.D.Ellis et al., hep-ph/0111434.